

SLR, GRACE and SWARM gravity field determination and combination

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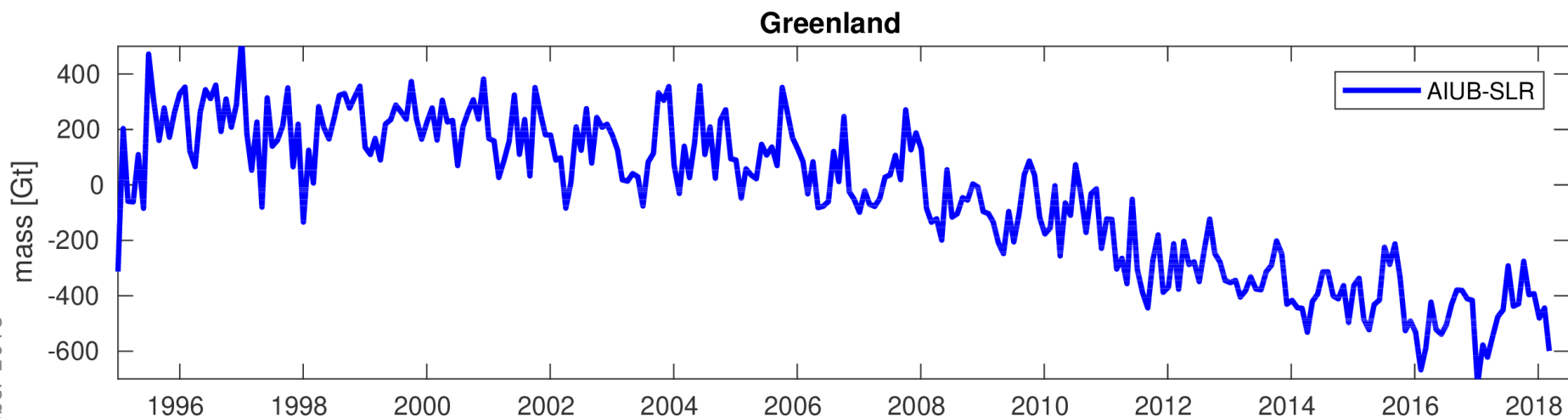
³Bundesamt für Kartographie und Geodäsie, Frankfurt, Germany

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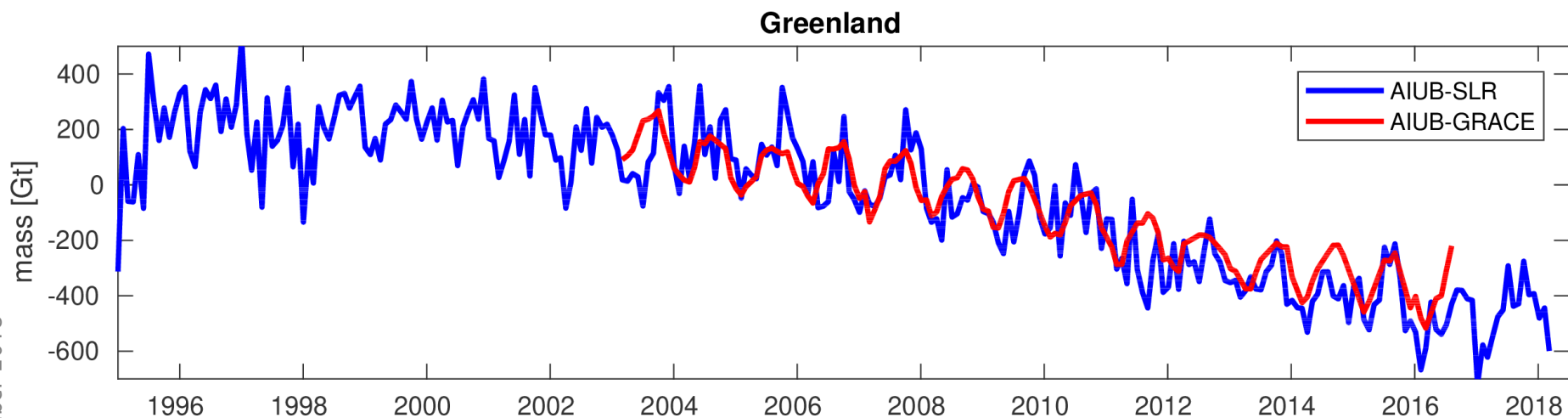
- Monthly mass variations in Greenland:
 - SLR
 - GRACE
 - SWARM
- Interpretation:
 - Spatial resolution
 - Spectral leakage
- Combination of normal equations:
 - SWARM + SLR
- Summary and Outlook

Ice melt in Greenland from SLR



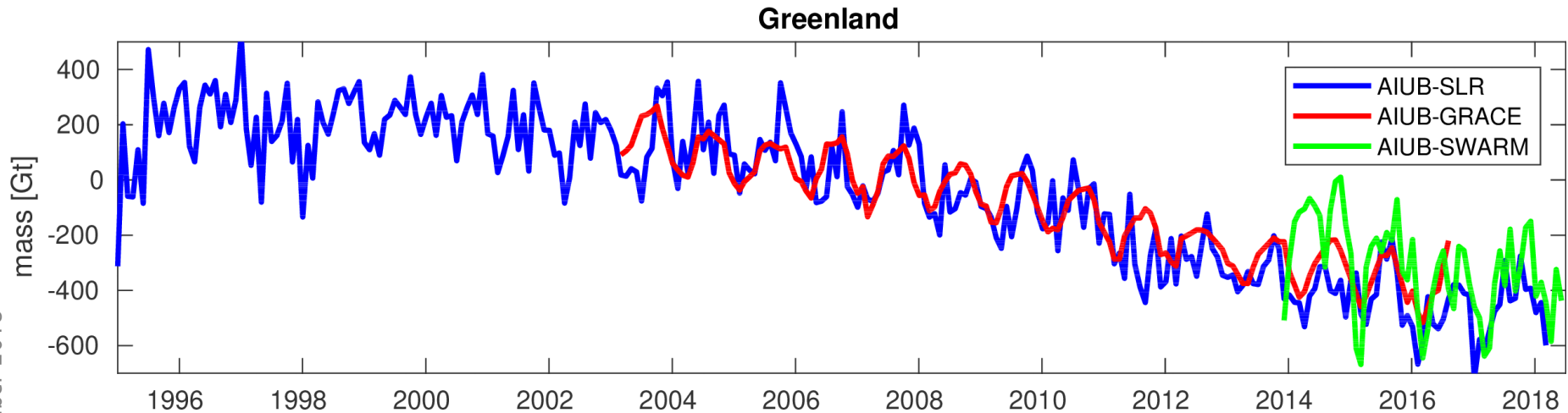
- LAGEOS 1+2: 30 d solutions based on 10 d arcs.
- SLR–LEOS (Beacon–C, Ajisai, Starlete, Stella, Larets, Lares): 30 d solutions based on 1 d arcs.
- Gravity field: $5 \times 5 + C_{61}$ and S_{61} ; C_{50} constrained.
- A priori gravity: static 7 y GRACE (AIUB–APR).
- A priori orbits: LAGEOS own predictions, LEOS CPF

Ice melt in Greenland from GRACE



- GRACE GPS+K-band: monthly 90 x 90 gravity field solutions, truncated at degree / order 6.
- Degree 2 excluded.
- Degree 1 fixed to 0.
- No filter applied.

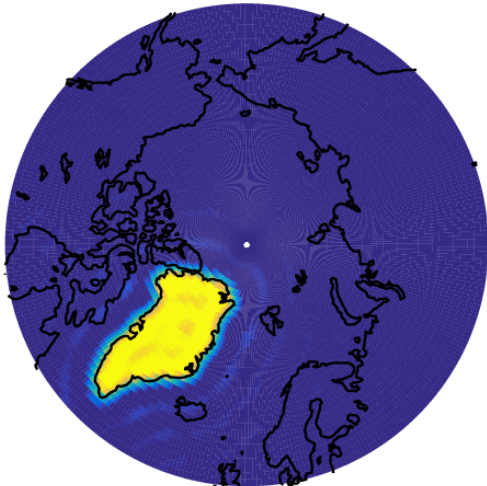
Ice melt in Greenland from SWARM



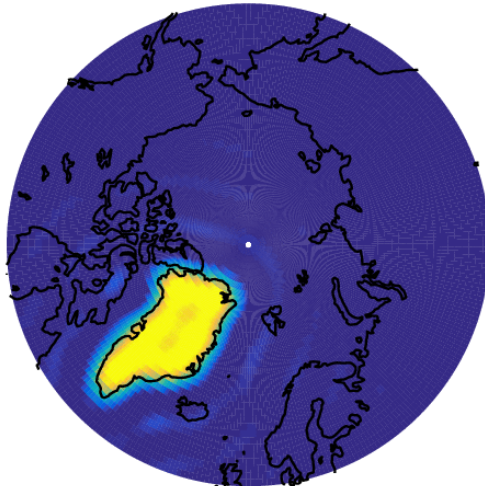
- **SWARM GPS: monthly 70 x 70 gravity field solutions, truncated at degree / order 6.**
- **Degree 2 excluded.**
- **Degree 1 fixed to 0.**
- **No filter applied.**

Spatial resolution and leakage

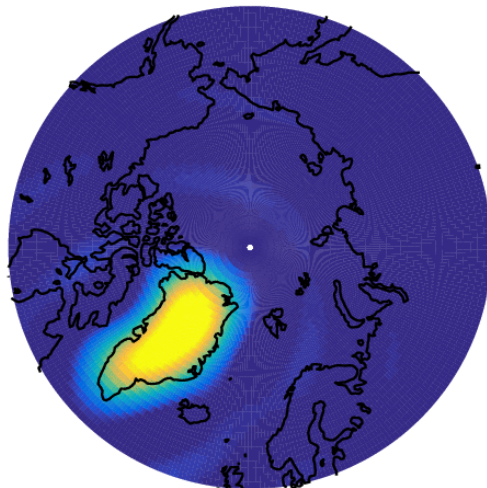
reproduced mass (90): 94%



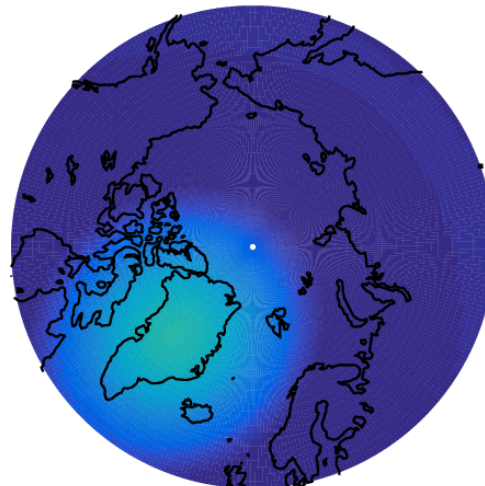
reproduced mass (60): 91%



reproduced mass (30): 82%



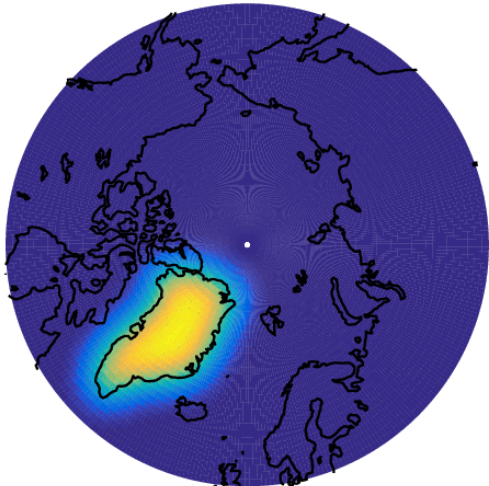
reproduced mass (10): 40%



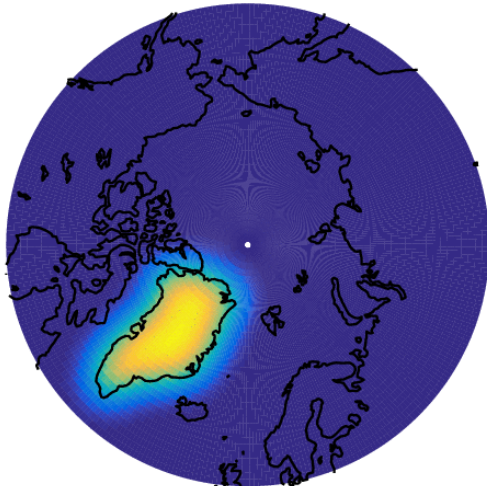
- The truncation of a spherical harmonic expansion leads to signal leakage.
- Sensitivity for monthly mass variations:
 - GRACE : 60–90
 - SWARM: 12–20
 - SLR: 6–10
- With knowledge about the original mass distribution leakage can be corrected by scaling.

Spatial resolution and leakage

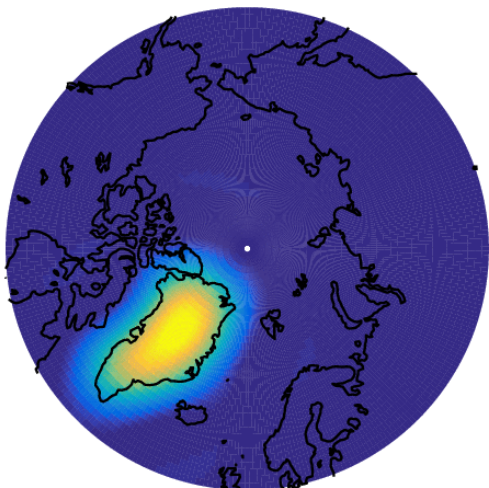
reproduced mass (90): 73 %



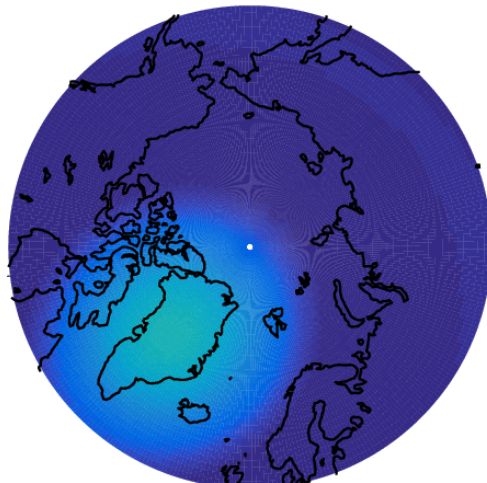
reproduced mass (60): 73 %



reproduced mass (30): 71 %

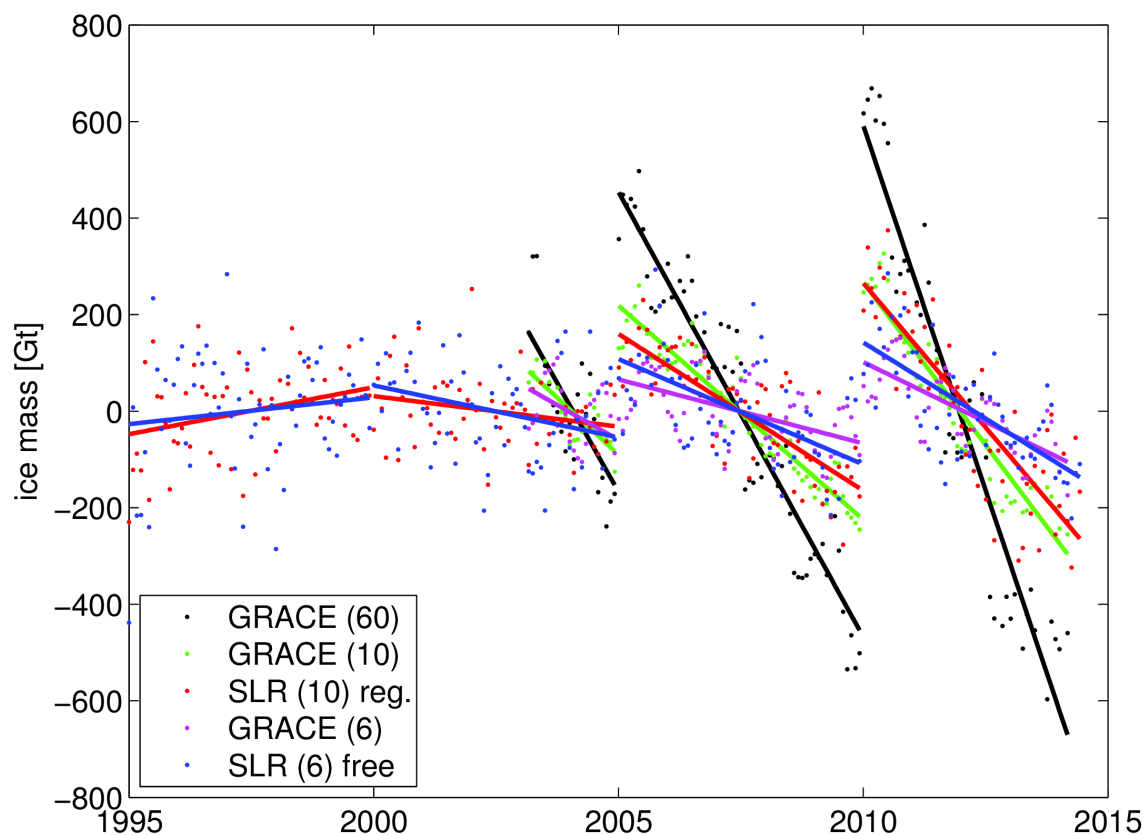


reproduced mass (10): 38 %



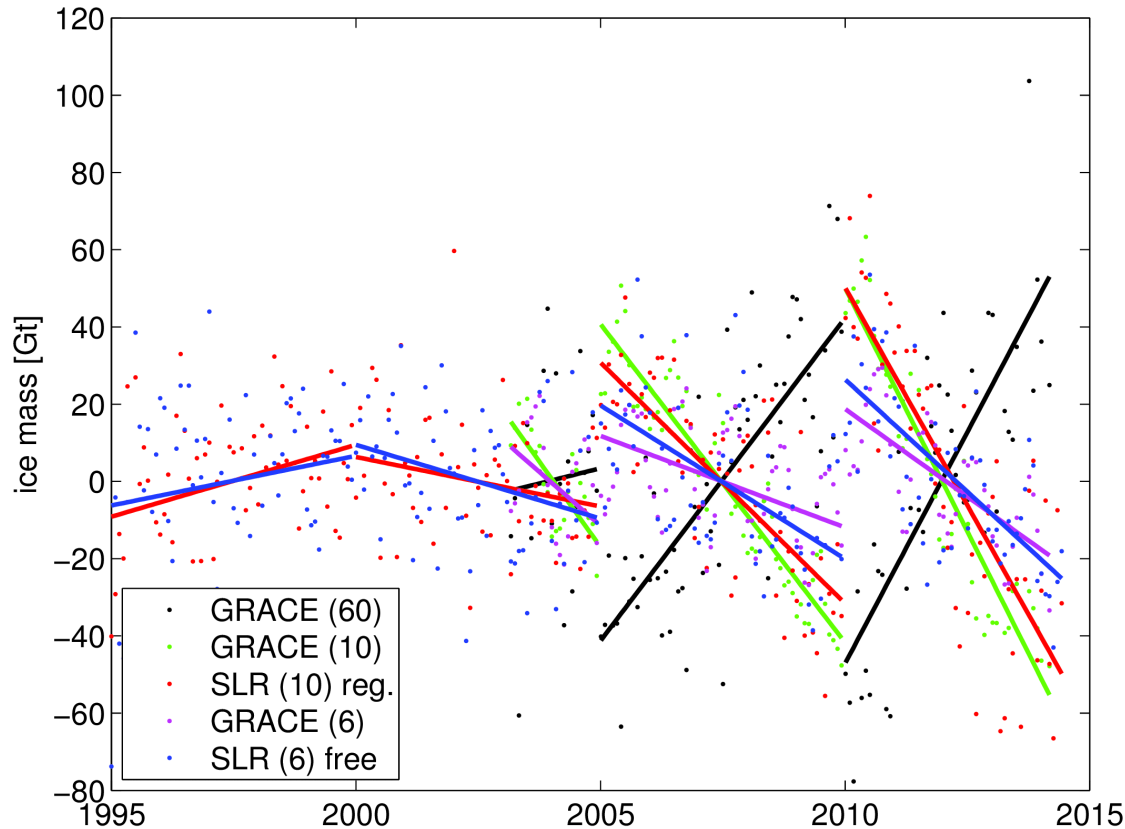
- Common filters (e.g. Gauss 300km) lead to drastic leakage even for GRACE.
- All signal above degree 60, and significant signal above degree 30 is attenuated!
- In case of SLR no filter is applied.

Ice mass change: Greenland Coast



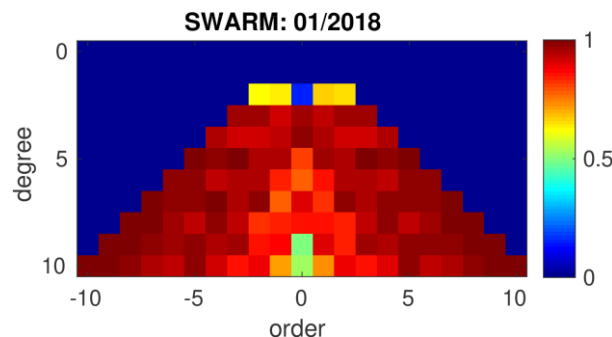
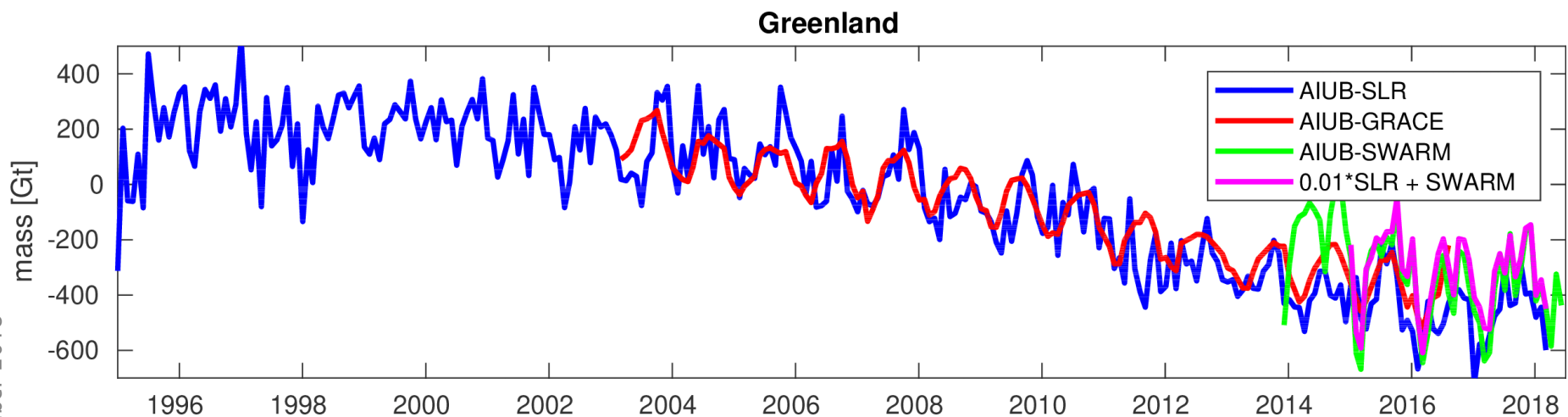
- SLR and GRACE provide consistent mass trends when truncated at the same degree / order.
- By scaling, the original amount of mass loss can be recovered almost completely (but not the spatial detail).

Ice mass change: Greenland Inland



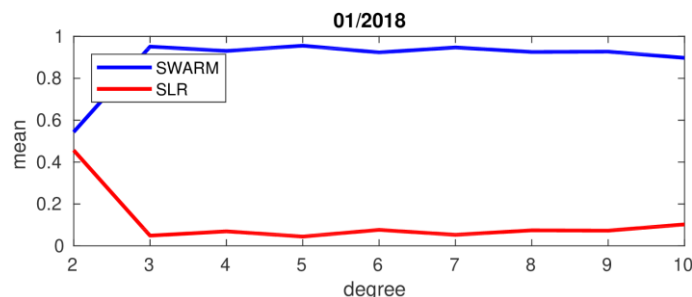
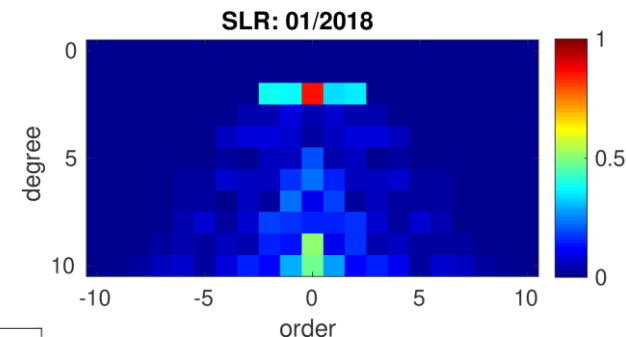
- Details at small spatial scales are lost. A separation between Greenland coast and inland is not possible with SLR.

Combination of NEQs: SWARM + 0.01 * SLR

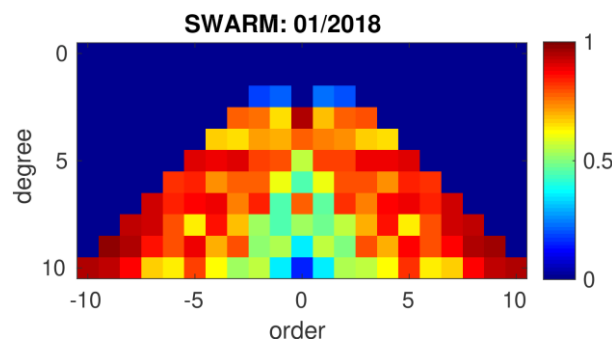
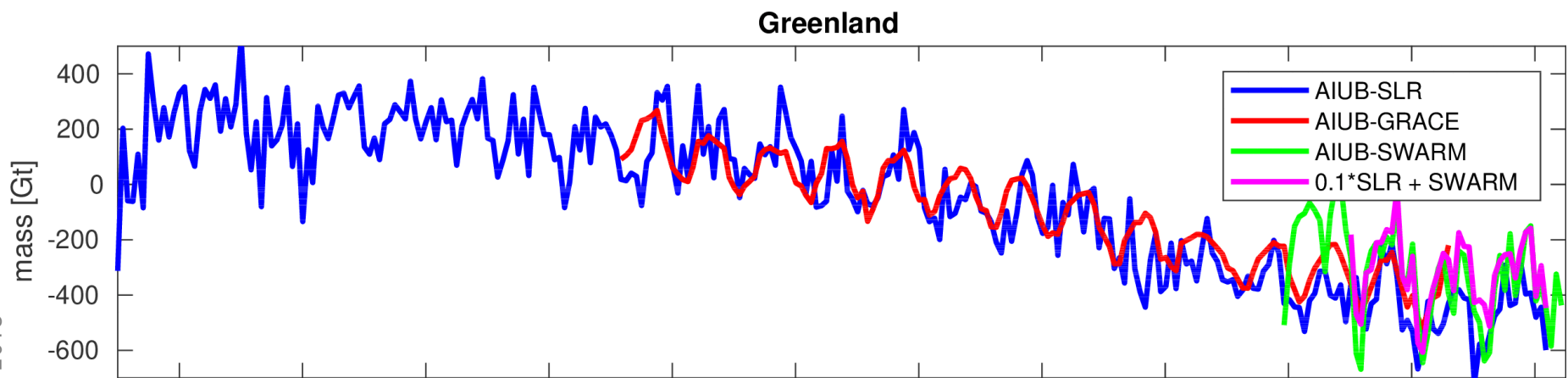


**Mean contribution
per degree.**

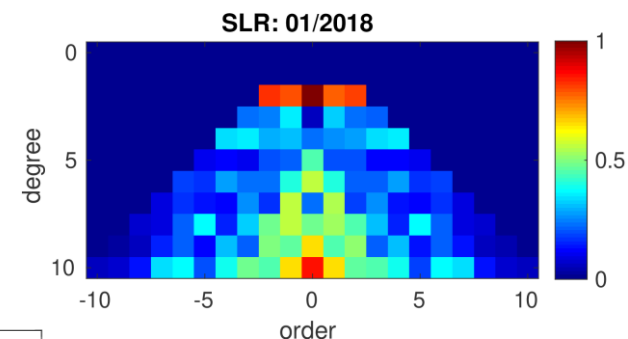
**Contribution
analysis per SH
coefficient.**



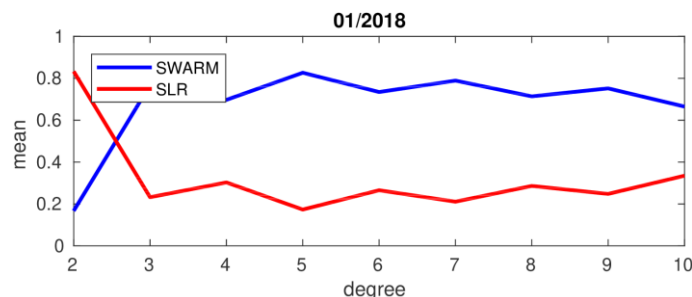
Combination of NEQs: SWARM + 0.1 * SLR



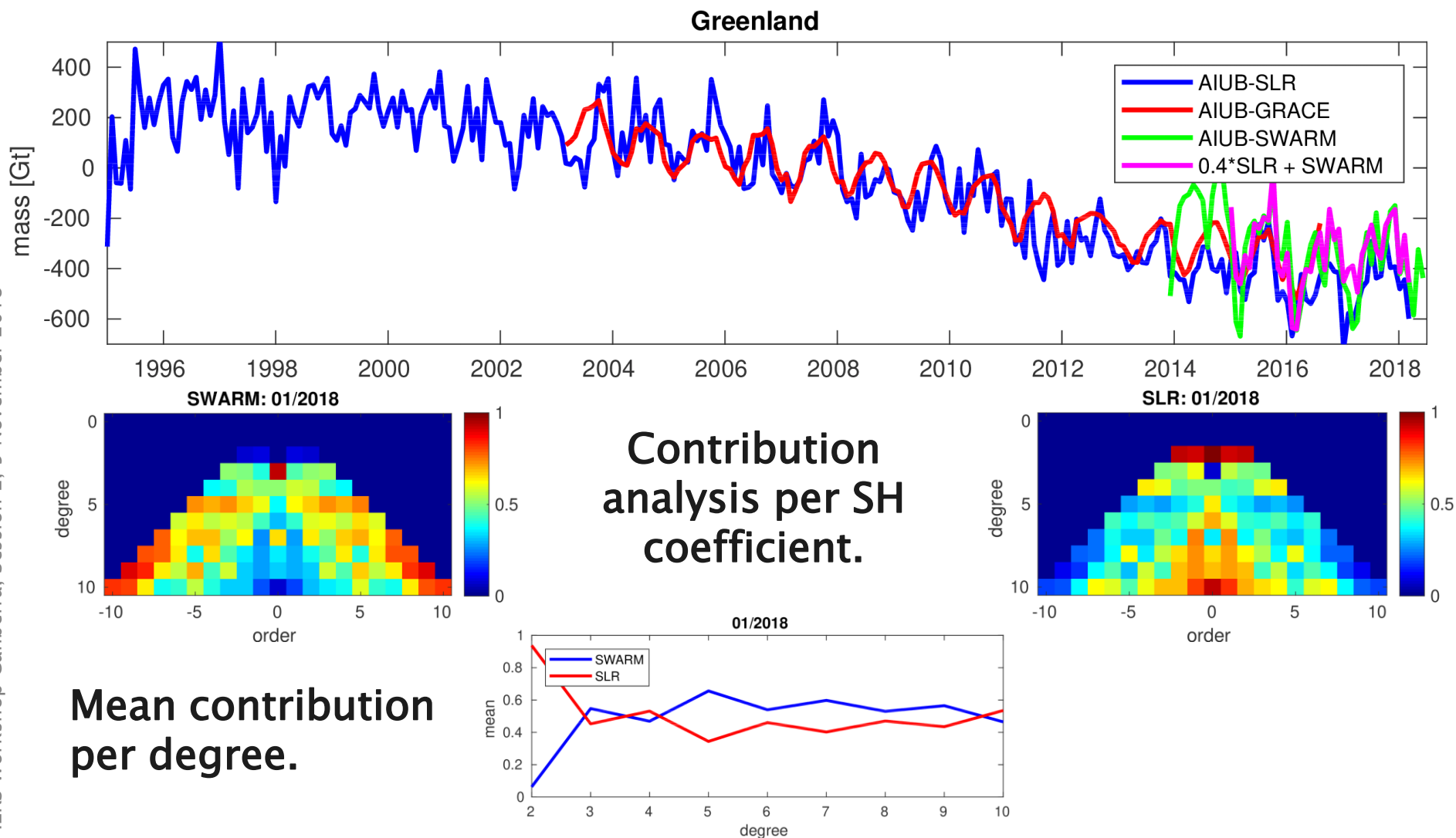
Contribution
analysis per SH
coefficient.



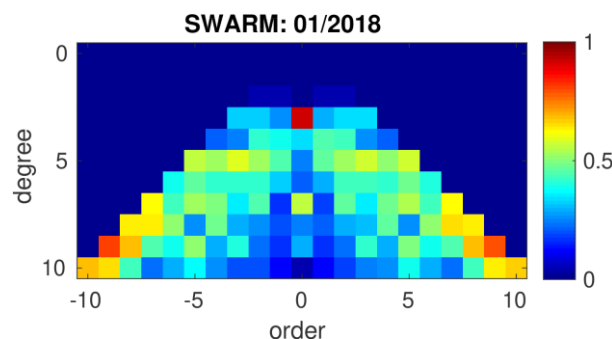
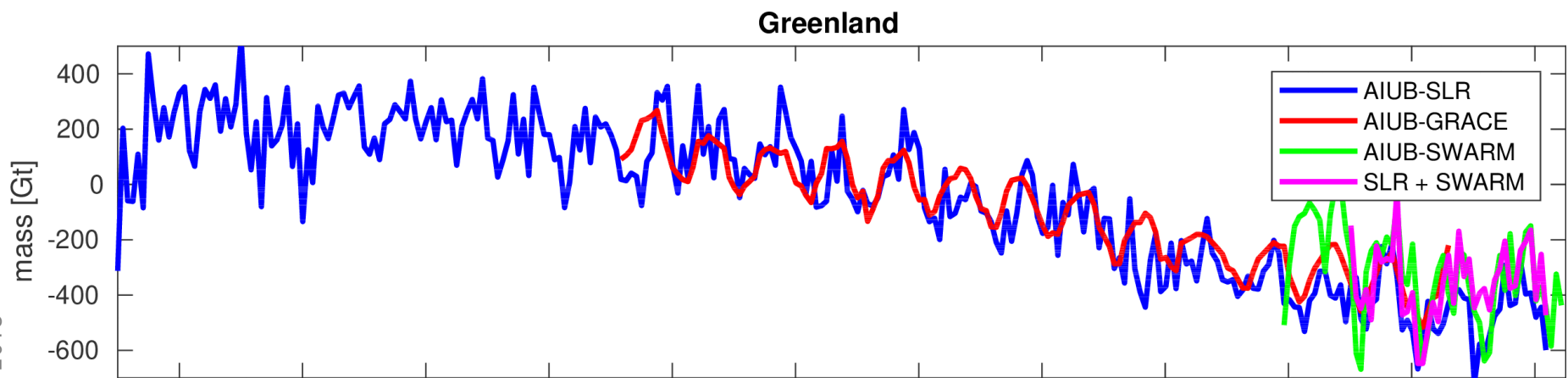
Mean contribution
per degree.



Combination of NEQs: SWARM + 0.4 * SLR

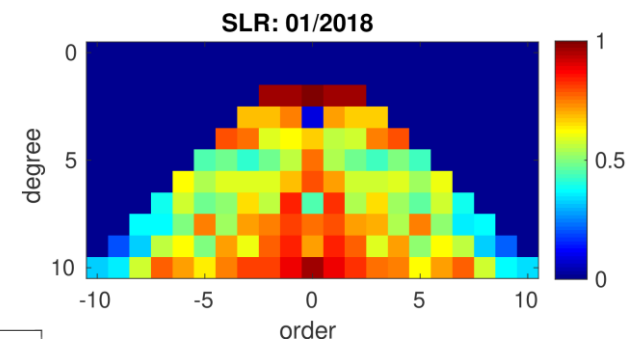
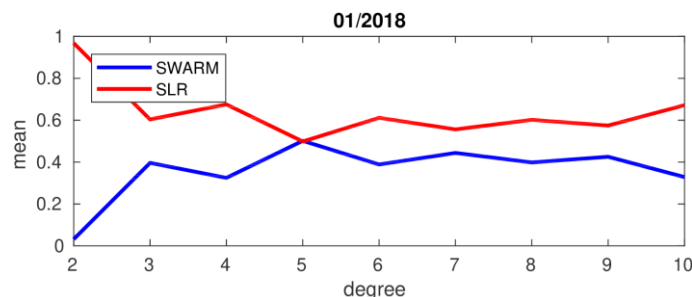


Combination of NEQs: SWARM + SLR

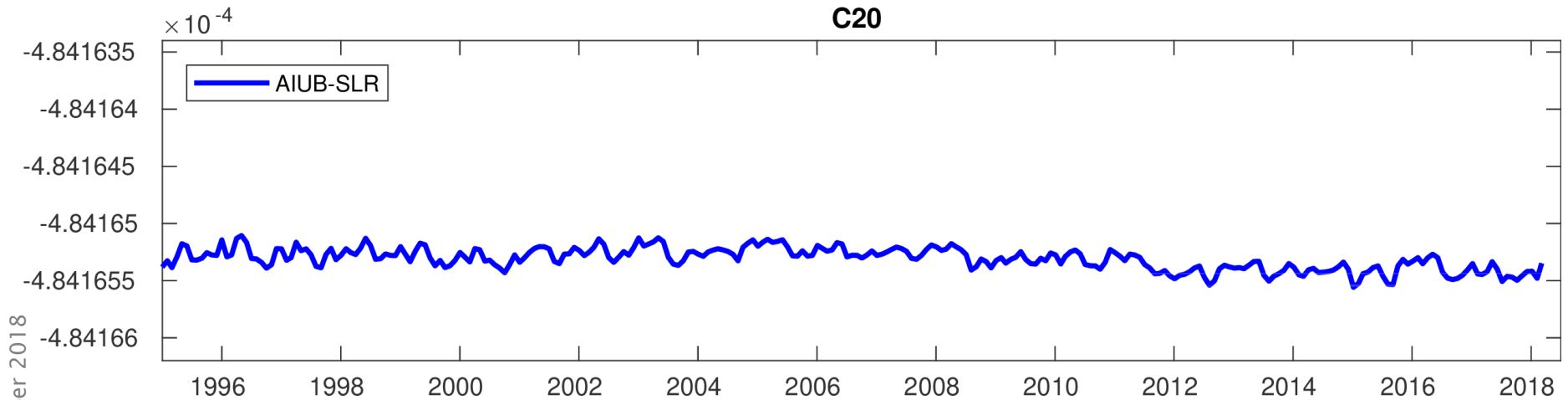


**Mean contribution
per degree.**

**Contribution
analysis per SH
coefficient.**

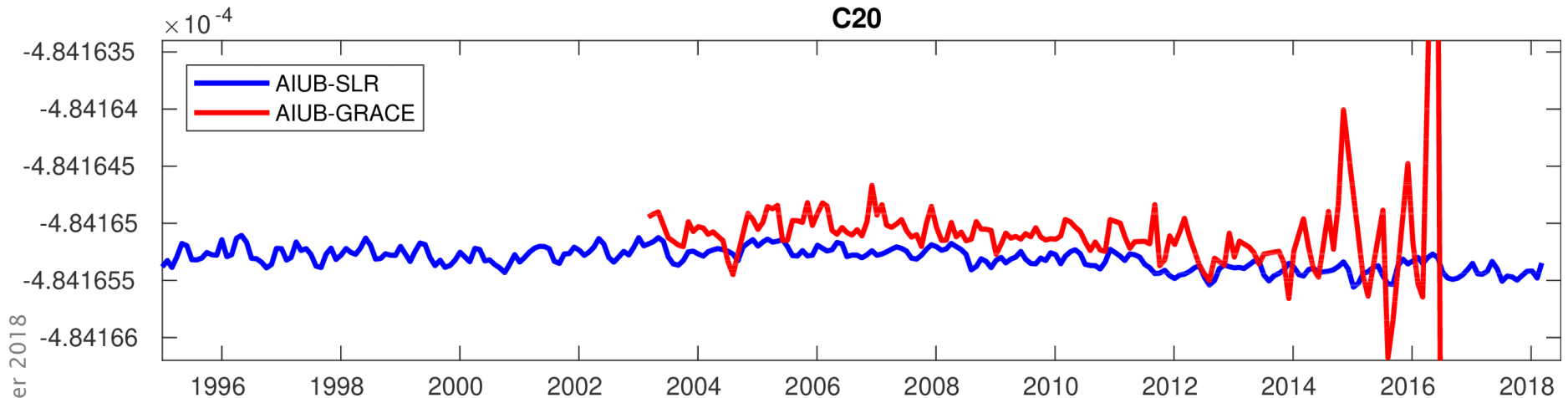


C20



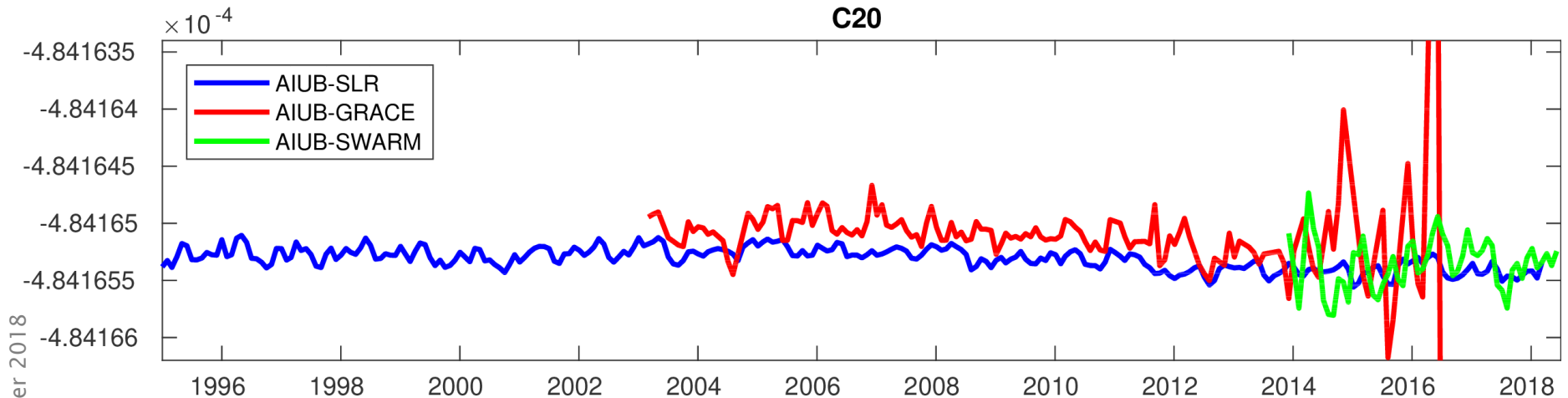
- LAGEOS + SLR-LEOs: 30 d C_{20} values

C20



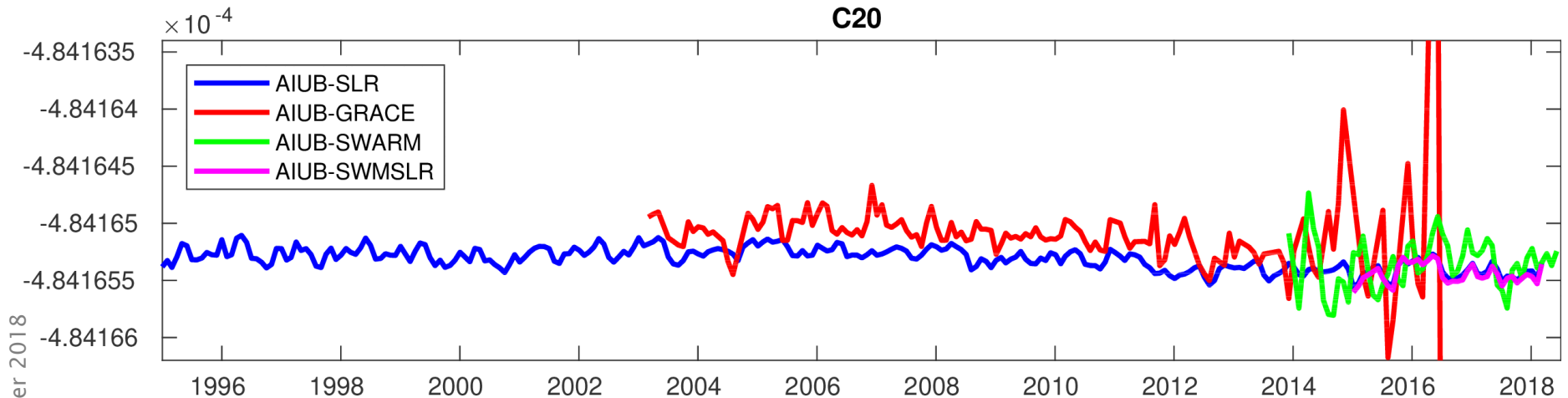
- LAGEOS + SLR–LEOs: 30 d C_{20} values
- GRACE: monthly C_{20} values, strong correlation with accelerometer temperature

C20



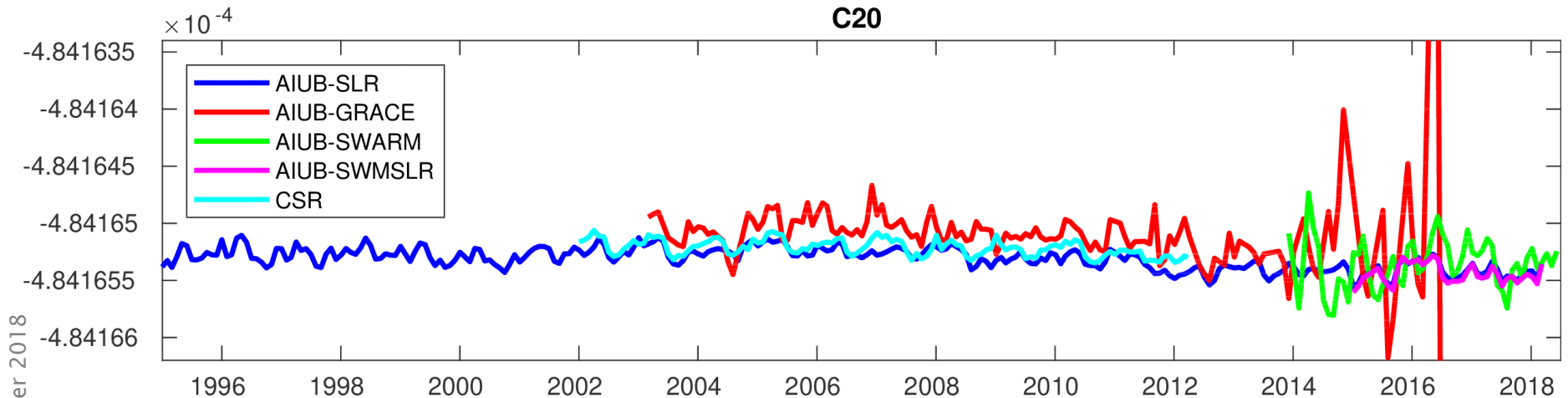
- LAGEOS + SLR–LEOs: 30 d C_{20} values.
- GRACE: monthly C_{20} values, strong correlation with accelerometer temperature.
- SWARM: monthly C_{20} values (no accelerometers used for signal separation).

C20



- LAGEOS + SLR–LEOs: 30 d C_{20} values.
- GRACE: monthly C_{20} values, strong correlation with accelerometer temperature.
- SWARM: monthly C_{20} values (no accelerometers used for signal separation).
- SLR + SWARM: C_{20} dominated by SLR

C20



- LAGEOS + SLR–LEOs: 30 d C_{20} values.
- GRACE: monthly C_{20} values, strong correlation with accelerometer temperature.
- SWARM: monthly C_{20} values (no accelerometers used for signal separation).
- SLR + SWARM: C_{20} dominated by SLR
- Reference CSR: monthly C_{20} values for GRACE

Summary and Outlook

- Truncated to the same spherical harmonic resolution the three space geodetic techniques SLR, high-low-SST (GPS) and low-low-SST (K-band) provide comparable ice mass trends.
- Taking spectral leakage into account the low resolution SLR mass trends are in agreement with high resolution GRACE results.
- Best SLR + SWARM combination results are achieved with equal weighting.